AL/HR-TR-1994-0066

ARMSTRONG LABORATORY

WARFIGHTING TRAINING R & D IN THE POST COLD WAR ERA-- WITH A SPECIAL EMPHASIS ON SYNTHETIC ENVIRONMENTS

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November 1994

Final Technical Report for Period October 1992 - February 1993

Approved for public release; distribution is unlimited.

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This report has been reviewed and is approved for publication.

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REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	November 1994	Interim Paper - October 1992- February 1993

4. TITLE AND SUBTITLE
Warfighting Training R&D in the Post Cold War Era-- With a Special Emphasis on Synthetic Environments

5. FUNDING NUMBERS
PE - 62205F
PR - 1123
TA - 25
WU - 16

6. AUTHOR(S)

Dee H. Andrews

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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Mesa, AZ 85206-0904

8. PERFORMING ORGANIZATION REPORT NUMBER
AL/HR-TR-1994-0066

9. SPONSORING/MONITORING AGENCY NAMES(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Armstrong Laboratory Technical Monitor- Dr Dee H. Andrews, (602) 988-6561. Also published in the February 1993 issue of Educational Technology, pp 36-40.

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The article discusses warfighting training as an integral part of military missions and functions, and its impact on one of the Office of the Director for Research and Engineering's seven Scientific and Technology (S&T) Thrusts, i.e., Synthetic Environments, on future training strategies and technologies.

14. SUBJECT TERMS

Educational Technology	SIMNET	Technology Transfer	Warfighting
Military Training	Simulation	Training	
Modeling and simulation	Synthetic Environments	Thrusts	

15. NUMBER OF PAGES
12

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

PREFACE

This report documents research conducted at the Armstrong Laboratory, Human Resources Directorate, Aircrew Training Research Division (AL/HRA).

The effort was conducted under Work Unit 1123-25-16, Simulation and Modeling Technology Support. The laboratory principal investigator was Colonel Lynn C. Carroll, AL/HRA. The project scientist was Dr Dee H. Andrews, AL/HRAT.

The attached article was published in the February 1993 issue of Educational Technology, pp 36-40, and discusses Synthetic Environments in the warfighting training research and development arena. Synthetic Environments is one of the seven Science and Technology (S&T) Thrusts defined by the Office of the Director for Research and Engineering (ODR&E), that "represent the demands being placed on the S&T program by the users' most pressing military and operational requirements."

Warfighting Training R & D in the Post Cold War Era—with a Special Emphasis on Synthetic Environments

Dee Howard Andrews
Contributing Editor

It is with a great sense of satisfaction and relief that we see the end of the Cold War era and the dawn of freedom for hundreds of millions of fellow inhabitants of this fair planet. Decades of sacrifice, both in terms of precious lives and national treasure, have brought us to the beginning of a "New World Order." However, despite our excitement about the possibilities ahead, our past experience with the end of conflicts, both hot and cold, has taught us that dangers to hard-won freedoms always seem to rear their ugly heads. As a saying popularized during the Desert Storm campaign goes, "Freedom isn't free."

With the fall of Communism it is clear that we no longer require a defense structure as large as we needed for the last few decades. However, it is also clear that a well-conceived security strategy, and the force structure to carry it out, is still very much required. As our national leaders have pondered and debated this new strategy over the last few years a number of concepts and directions have emerged. Because these plans for a new defense strategy still rely heavily on well-trained airmen, soldiers, sailors, and marines it is worth discussing future directions that will be emerging in military warfighting training R&D, especially with regards to educational technology.

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A key reality in the post Cold War era will be considerably reduced resources for defense. Few debate the wisdom of shifting funds to other uses, but that shift will obviously make the maintenance of military readiness via training more challenging. Less money for driving tanks, sailing ships, and flying airplanes will mean the operators and maintainers will have less opportunity to learn, maintain, and improve their skills while they are on the job. Less money for large-scale exercises will mean it will be more difficult for senior and mid-level leaders to gain the warfighting skills required to successfully use the new force structure effectively. Fewer overseas bases will require leaders and their forces to practice deployments, possibly in territory that they have never seen before.

Yet, at the same time that the resources shrink, the warfighting skills that future troops must master promise to continue to grow more sophisticated. The geo-political situations that military leaders must deal with will become more complex, as the future threats become less well-defined than in the past.*

How will the Defense Department cope with these changes? How will military trainers produce training systems for warfighting skills that will allow military personnel to maintain required states of readiness while also saving money?

Key Technologies and Science and Technology Thrusts

The Department of Defense (DoD) has determined that R&D of all types will be a major foundation for much of the military's future activities and developments. The DoD has recently defined the types of exploratory and advanced R&D that should be performed given the current assessment of potential post Cold-War threats and overall military strategy. The Office of Director for Research and Engineering (ODR&E) has defined a group of eleven exploratory Key Technologies that will be given significant emphasis in the coming years. They are:

*For purposes of this article I am discriminating between "warfighting" training and procedures training. Procedures training examples are learning to drive a tank, fix an engine, fly an airplane. Warfighting training refers to giving warriors the skills necessary to conduct tactical engagements. Once a warrior has graduated to a warfighting unit, continuation training will concentrate on learning and practicing individual and team skills that will be necessary should the unit go to war. If formal schools can be thought of as "baccalaureate" training concentrating on operational skills, then continuation training can be thought of as a "graduate school" that concentrates on warfighting skills.

- Computers
- Software
- Sensors
- Communications Networking
- Electronic Devices
- Environmental Effects
- Materials and Processes
- Energy Storage
- Propulsion and Energy Conversion
- Design Automation
- Human-System Interfaces

In a July 1992 document, ODR&E also defined seven Science and Technology (S&T) Thrusts that, "represent the demands being placed on the S&T program by the users' most pressing military and operational requirements." The users referred to can range from the Chairman of the Joint Chiefs of Staff to the warrior in the field. The seven S&T Thrusts are described below. The descriptions in each thrust are taken from the ODR&E 1992 document.

• **Global Surveillance and Communications.** This thrust will develop the global aspects of emerging surveillance and communications capabilities. It will contribute to the seamless exchange of information with more local communications and sensing systems described in several of the other Thrusts, particularly Precision Strike.

• **Precision Strike.** Precision Strike is a set of integrated, multi-Service capabilities for locating, identifying, and killing high-value, time-sensitive military ground targets. Scud missiles would be examples of likely Precision Strike targets.

• **Air Superiority and Defense.** The S&T strategy. . .will be to develop and demonstrate technologies providing a dramatically improved or completely new capability to defend against and engage tactical ballistic missiles and stealthy manned aircraft, cruise missiles, and helicopters.

• **Sea Control and Undersea Superiority.** This Thrust has been established to respond to the military requirements posed by the growing need for naval forces to operate in coastal areas. The challenge is to identify, develop, and demonstrate capabilities for distributed, fixed, and mobile platforms.

• **Advanced Land Combat.** The primary goal of the future advanced land combat force is to exploit advanced technologies to ensure the rapid projection of forces to defend, deny, and overwhelm enemy forces, anywhere, at any time.

• **Synthetic Environments.** This Thrust will deliver as its legacy the ability to routinely construct, on demand, a robust variety of synthetic environments that will enable fundamental changes in how mainline defense functions are accomplished in the 2000s. Synthetic environments are internetted simulations that represent activities at a high level of realism, from simulations of theaters of war to factories and manufacturing processes. These environments are fundamentally different from the traditional simulations and models known today. They are created by confederations of computers, connected by local and wide area networks, and augmented by superrealistic special effects and accurate behavioral models. They allow complete visualization and total immersion into the environment being simulated.

• **Technology for Affordability.** The legacy of investments in Technology for Affordability will be a new mode of defense manufacturing.

Synthetic Environments: A Crucial Part of Future Military Training

Since the human is such an integral part of any military mission and function, it is clear that training will have an impact on, and in turn be impacted by, all eleven key technologies and seven S&T Thrust areas. However, the Thrust Area called "Synthetic Environments" (SE) will be especially crucial to future training strategies and technologies. All of the current training devices and simulators that the military presently uses will be subsumed under the broad category called SE. Yet, as the definition of SE above points out, SEs will be more than the sum of a simulator or group of simulators. The goal is to build networks of simulators, often at long distances from each other, so that warriors can be immersed in combat-like environments that are realistic enough to cause whole combat units to fight as though they were in an actual engagement.

During the 1980's the Defense Advanced Research Projects Agency and the Army developed the first large scale, inter-netted simulation. SIMNET was designed to provide armored units a synthetic environment in which to learn and practice tactics. Dozens of relatively low-fidelity simulators were built and linked and a variety of terrain data bases were constructed. SIMNET demonstrations showed that warriors at various sites around the country could be aligned to fight with and against each other.

Desert Storm showed that the military has in large measure been successful in achieving the goal described by the motto, "Train like we fight, and fight like we train." Many of the missions successfully undertaken by U.S. forces had already been trained for and practiced long before the war started. This training took place not only in the Persian Gulf region as the troop build-up proceeded, but the training had been performed for many years back in the U.S. and other regions through the use of simulators and with large scale exercises

on training ranges with instrumented measurement systems.

At places like the Army's National Training Center at Ft. Irwin, California, and the Air Force's Red Flag Exercices in Nevada, the services have since the Vietnam War built up considerable capability to have whole battalions, wings of aircraft, and battle groups of ships train against expert adversary proxies. The military has found that nothing can substitute for having large combat forces train against capable foes who use strategies and tactics like those of real threats. When U.S. Forces in Desert Storm encountered Soviet tactics and equipment, they were ready, because they had been training against just such a threat for many years.

The concept of SE is not just to link disparate simulators of various types but also to be able to link actual combat equipment on ranges or at sea with simulators. The ODR&E has stated the following vision for what is called the Synthetic/Electronic Battlefield:

"The vision for this Thrust requires the creation of a synthetic environment; specifically, a synthetic or electronic battlefield. The battlefield will integrate representations of the forces of all relevant DoD components (and those of our allies)—it will have a "joint" orientation by design. The representations will include simulators, models, and wargames, as well as instrumented equipment and ranges. The outputs will be a seamless integration of interactive warfighting representations, many involving man-in-the-loop simulations and wargames, but many others based on validated or certified models of warfighting behaviors, including semi-automated forces. The technology will be used primarily for acquisition and for training and readiness."

In addition to providing increased realism to training, SEs will provide fertile ground for training research. Examples of issues that will need to be researched if SEs are to reach their full training potential are:

- How best can combat units that train with and against each other from long distances receive joint training? This includes the technology necessary to allow briefing before and debriefing after an exercise.
- In addition to the long-distance training technology required, it is likely that new training strategies will also be necessary. What form should those strategies take?
- A variety of measurement and evaluation issues will need to be addressed. For example, what measures of validity should we ascribe to an engagement where an aircraft unit that flies its actual aircraft on a range defeats an aircraft unit that flies networked simulators?
- What role should instructors play in a synthetic battlefield? We might assume warriors will not be allowed to participate in synthetic battlefield SEs until they have mastered their individual and crew skills. That is, the synthetic environment will be "graduate schools." If that is the case, will instructors in the normal sense of the word be required?
- Taking the above point somewhat further, is it true that we will not want warriors to participate until they are proficient in individual and crew skills. Might SE engagements act as "advanced organizers" for relatively new warriors?

Many other research questions will need to be answered before we can truly say that SEs have attained the full measure of their potential.

Potential Contributions of Military Synthetic Environment R&D to Educational Technology

The military's investment in educational technology over many decades has produced significant transfers to the field of education and training as a whole. Computer-based instruction, instructional systems approaches to instructional development, and computer managed instructional systems are just a few of the areas that have received considerable advancements as a result of military investment.

SEs hold considerable promise for contributing significantly to civilian education and training in the future. Here are some possible contributions:

1. To create truly realistic SEs, researchers, engineers, and computer scientists will have to improve existing models and simulations of the real world, vehicles that interact with each other and with the real world, and human representations. While the modeling and simulation community has developed all of these models to a considerable extent, dramatic improvements are anticipated.

- Real-world models will increase in their capability to simulate environmental characteristics such as terrain, weather, the atmosphere, and ambient light. Civilian educators and trainers may benefit from these developments as they create virtual worlds for students to explore. For example, teachers will be able to take students to any planet in the universe for an exploration session.
- Improvements in weapons systems models will increase our capability to model moving objects in any virtual reality application. An example of the benefits these better models will provide is a traffic engineering class that will be able to see how their traffic system designs affect real-world models of cars.
- SEs will eventually provide simulations of

many thousands of air, land, and sea vehicles for military engagements. It will therefore be necessary to allow higher-echelon commanders the option of exercising these large SEs without necessarily having thousands of humans actually manning these thousands of weapons systems. These "autonomous platforms" will be "manned" by models of human operators. They will be intelligent enough to react to their environments in much the same way as a live human. Improvements in our ability to model these representations of humans will press our understanding of human cognitive processes and psychomotor behavior. These improvements should help the field of educational technology in a number of ways. For example, intelligent tutoring systems should benefit from models and tools that aid in accurately representing student and instructor knowledge bases.

2. SE research and development should produce modeling tools that will allow accurate environmental, vehicle, and human data bases to be created in much shorter time frames than are now possible. If you've ever attempted to build computer-based simulations for training, you know how long it can take to create even a relatively simple, interactive representation of terrain, or a vehicle, or a human.

3. To meet all the goals and objectives for SEs, the Department of Defense will be developing tools and pathways for large-scale networking. Figure 1 shows a current version of the Defense Advanced Research Projects Agency's Terrestrial Wideband Network. Again, the vision is that perhaps hundreds of different sites will eventually be linked together. These sites will include actual training ranges, simulation facilities, and sites that run computerized war games. A variety of technical issues have already been resolved and many more await resolution. For example, a number of organizations from the Department of Defense, industry, and academia have been developing a standard protocol for networking simulators. The goal is to avoid the development of a brand new networking protocol every time a new networking application is devised.

Another area of great activity has been the development of a terrestrial wide-band network with enough bandwidth to pass the necessary information between simulators. The current networking protocol standard does not require each simulator on the network to know everything that every other simulator knows. Rather, data packets are passed around the network on a frequent (less than one second) basis that give only the current position and heading of each vehicle being simulated. For example, what each simulator shows on their radar model is of no importance to every other simulator, and thus that data is not passed around the network.

By keeping the network free of any but the most critical information it is possible to have a fairly large number of simulators talking to each other. However, even this system runs into overload problems as the number of simulators on the net increases into the hundreds or thousands. For this reason, considerable effort is being spent on increasing the available bandwidth of current and future networks.

Civilian education and training should benefit from this networking R&D. For example, as computer-based training systems provide more sophisticated simulations, and as the need grows to network many students and facilities together, standard networking protocols and wider bandwidths will be required. It is a fairly safe bet that if dozens or hundreds of high-fidelity flight and tank simulators can be linked together, then that same technology should allow possible thousands of computer-based training stations to be interactively linked.

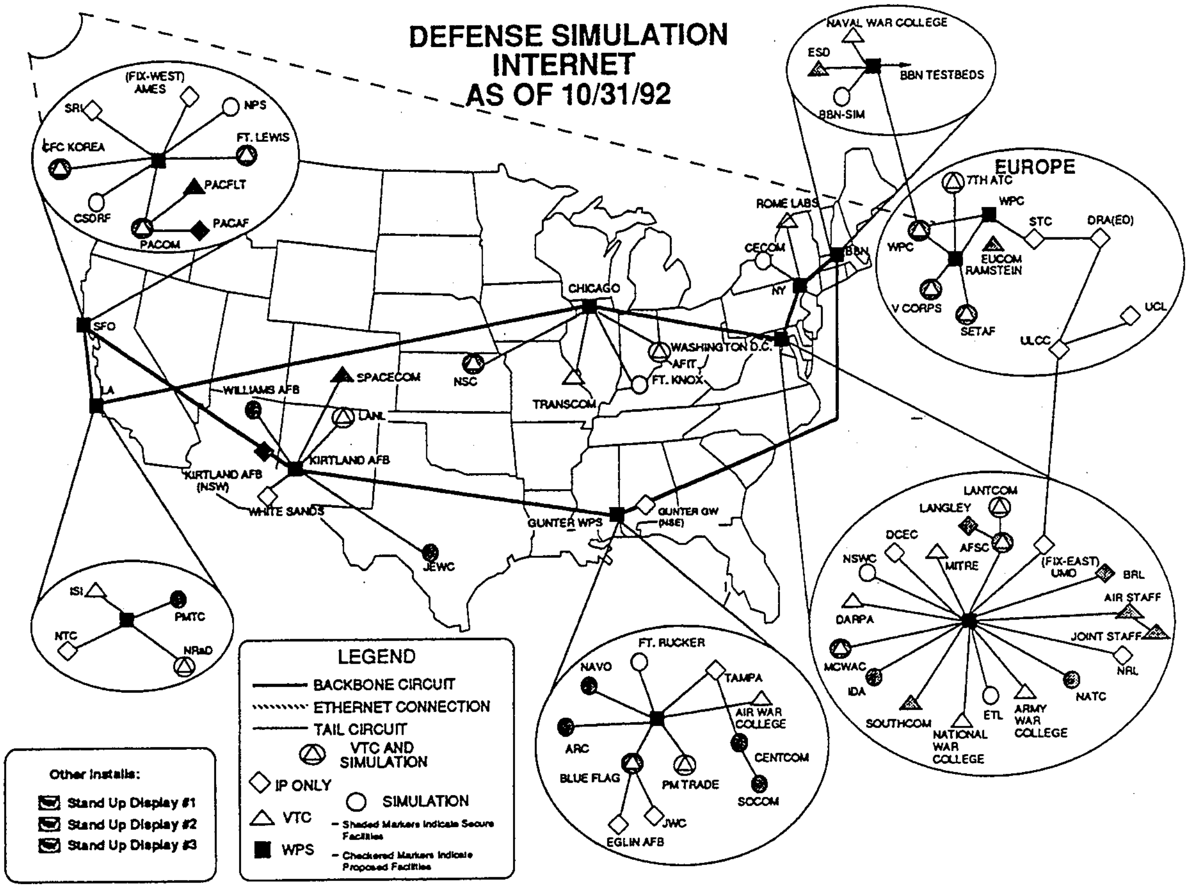
4. While existing flight, land, and sea vehicle simulations can provide a high level of physical and functional fidelity, they do so at high cost, often in the millions of dollars. The work in SE should produce interface vehicles ("access tools") that are affordable. Some military training planners envision literally thousands of SE access tools being linked. Clearly, cost-effective access tools will be a *must*. To produce low-cost SE systems it will be necessary to bring down the cost of SE access tool components (e.g., visual displays, visual image generators, vehicle control devices, haptic devices, performance measurement systems). Experience in the development of these components over the last few years has produced promising results. Access tool components in the tens of thousands of dollars are now possible. More cost reductions can be expected.

Civilian education and training will benefit from these advances. Current commercially available, reasonably priced virtual reality components produce crude SEs when compared to the SEs produced by modern, high-cost flight simulators. Military sponsored R&D should produce virtual reality components that meet K–12, college, and industrial education and training budgets, while still producing high-fidelity SEs.

Conclusion

Keeping the peace in the post Cold-War world will produce many challenges, not the least of which is a shrinking budget. The Department of Defense has developed detailed plans for making the most of these shrinking budgets. The goal is

Figure 1



to maintain a smaller military force that is the best equipped and trained in the world. Science and technology will play key roles in providing superior weapon and training systems. During the recent Presidential elections all three candicates discussed the need for using technology to keep our military strong.

A major set of technologies that will keep military personnel well-trained are the modeling and simulation technologies required to build synthetic environments. SEs promise to provide improvements to current training approaches that will be: more effective, more efficient, and more gentle on the environment. As has happened so often in the past, these military training initiatives should effectively transfer to the civilian training and education world.

However, the transfer of technology has been, and will be, in two directions. The civilian sector has been producing, and will continue to produce, technologies that are extremely useful for military SE development:

- The entertainment industry has greatly accelerated the development of low-cost visual image generation and visual display technologies necessary for low-cost access tools.
- Non-DoD, cognitive psychologists have made significant strides in describing the nature of complex mental processes. This understanding has made possible the modeling capability necessary for autonomous, simulated adversaries.
- The communications industry has developed fiber-optic technology necessary for linking very large numbers of remotely sited models and simulators.

This dual-use approach to R&D that improves both military and civilian education and training will be a hallmark of the 1990s and beyond. □

The opinions expressed in this article are those of the author and do not necessarily represent the official views of the Department of Defense, the Department of the Air Force, or the Armstrong Laboratory.